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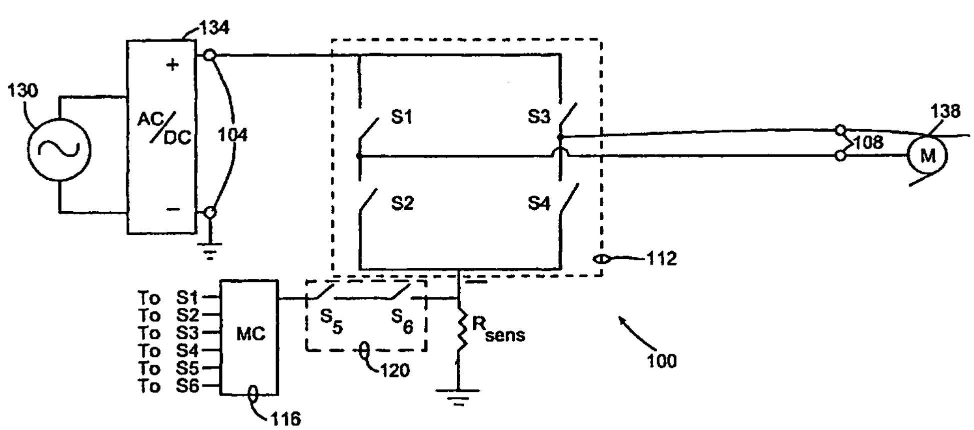
(54) Title: METHOD AND APPARATUS FOR CONTROLLING PULSE WIDTH MODULATION DEVICE



(57) Abstract

A pulse width modulation sensor system is provided in which a sensor (116) can be decoupled from the circuit so as to avoid transients. A switching circuit (120) can be coupled between the sensor and the pulse width modulation inverter switching circuit (112) and operated before a switching transition of the inverter switching circuit occurs. However, the sensing period is preferably implemented for a substantial portion of the period so as to be more responsive than conventional sample and hold techniques.

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Method and Apparatus for Controlling Pulse Width Modulation Device

CROSS-REFERENCES TO RELATED APPLICATIONS

This patent claims the benefit of U.S. Provisional Applications 60/126,771, filed March 29, 1999 and 60/164,326 filed on November 7, 1999.

BACKGROUND OF THE INVENTION

This invention relates generally to power supply circuits. More particularly, this invention relates to sensor systems used to control pulse width modulated output signals.

In power supply circuits, a common problem is that of transients and the effect of those transients on the rest of the system. With regard to Pulse Width Modulation (PWM) power supplies, transients are often created by the switching transitions of inverter switches. As an example, a typical PWM power supply is configured using an H-bridge inverter switching circuit made of insulated gate bipolar transistors (IGBT's). These IGBT's are controlled so as to pulse a voltage across a load. The magnitude of the output voltage is generally maintained constant, while the width of the pulse varies. With respect to induction motors, for example, the PWM waveform can be used to simulate a sine wave output voltage of a desired magnitude and frequency, including very low frequencies. Thus, a variable speed motor controller can be implemented for an induction motor through the use of PWM.

In order to control an electrical characteristic of a circuit or load being powered, a sensor is typically used to sense an electrical characteristic associated with the circuit or load. For example, a measurement of motor current can be used to determine the speed at which a known motor is operating. Then, this measurement can be used to provide feedback to the motor speed controller which adjusts the PWM scheme to control the speed of the motor.

In using these sensors, electrical transients can introduce errors into the sensed values and/or cause damage to the sensor circuitry. At least two methods have been attempted in the past to address this problem, namely filtering and sampling.

The filtering technique has involved use of a traditional analog low pass filter or a digital filter coupled to the electrical signal being sensed, e.g., filtering of a voltage signal. These filters typically require a long time constant in order to accomplish

the level of attenuation required for the worst transients. As a result of this time constant, however, the response time to respond to an overcurrent condition can result in damage to circuit elements. For example, in the case of IGBT's, a large overcurrent for more than 10 microseconds can cause damage to these switching transistors. Similarly, an overcurrent can damage a load if not corrected quickly. Thus, the filtering actually inhibits the protection of the power supply circuitry. Therefore, there is a need for a sensor system that is not affected by transients, yet, does not allow the rest of the circuit to be damaged.

Sampling is another technique that has been implemented in an attempt to avoid the problems caused by transients. In the case of sampling, the electrical characteristic is sampled for a short period within each output cycle. A sample and hold technique is used to accomplish this. However, since only a short time period during an entire cycle is sampled, this method cannot protect the circuit from abnormal behavior during the remainder of the cycle. For example, an overcurrent condition could go undetected and a motor could be damaged before the overcurrent is detected by the sample and hold circuit. Thus, sampling has failed to adequately address the problem as well.

Hence, there is still a need for a sensing system that overcomes disadvantages inherent in existing sensing systems and solves the problem of avoiding transients. Furthermore, there is a need for a sensing system that protects the sensor and/or circuit from damage.

SUMMARY OF THE INVENTION

The present invention overcomes disadvantages of earlier sensing system designs and provides inventive subject matter which satisfies needs left unfulfilled by the current state of the art.

One embodiment of the invention is advantageous in that it allows sensing to occur for a substantial portion of a cycle while still avoiding the effects of transient conditions.

Another embodiment is advantageous in that it removes the sensor from the circuit before a transient condition can cause problems, thus protecting the sensor from damage and avoiding an inaccurate result produced by the transient.

Another advantage offered by one embodiment of the invention is that it protects circuitry by monitoring for an extended period of time during an output waveform.

In accordance with one embodiment of the invention, a system is provided having an input to receive a DC voltage signal; a first switching circuit, such as an inverter circuit, is electrically coupled to the input and to an output; a sensor is coupled to the first switching circuit so as to sense a signal; a second switching circuit is coupled with the first switching circuit and the sensor so as to disconnect the sensor from the first switching circuit in order to avoid a transient.

A variety of switching systems are provided which can be implemented to disconnect the sensor from the first switching circuit, e.g., from the inverter circuit. A set of at least two switches configured in series can be used with different control signals opening each control signal's respective switch during a known transient causing event, e.g., the switching of an inverter switch. Alternatively, a parallel arrangement of two switches can be utilized, in which each control signal closes a switch during a portion of a half cycle and opens the switch upon the known occurrence of a transient causing event. In addition, a single switch could be used in which a single control signal is activated at least twice during an output signal cycle to open the switch during a known transient causing event, such as the switching of inverter switches which are known to cause transients.

Other and further advantages and features of the invention will be apparent to those skilled in the art from a consideration of the following description taken in conjunction with the accompanying drawings wherein certain methods and apparatuses for practicing the invention are illustrated. However, it is to be understood that the invention is not limited to the details disclosed but includes all such variations and modifications as fall within the spirit of the invention and the scope of the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a circuit in which a sensor is electrically coupled to an inverter circuit by a switching circuit that is configured to disconnect the sensor from the inverter switching circuit.

Figure 2 shows an alternative switching circuit that could be used in place of the switching circuit in Figure 1.

Figure 3 shows another alternative switching circuit that could be used in place of the switching circuits of Figures 1 and 2.

Figure 4 shows a flow diagram that illustrates the method of operation for decoupling the sensor from the inverter circuit.

Figure 5 shows a typical bipolar PWM waveform implemented by many power sources.

Figure 6 shows a unipolar PWM waveform implemented by other power sources.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

Referring now to Figure 1, an embodiment of the invention can be seen in circuit 100. Circuit 100 comprises a circuit to provide a DC voltage as an input to a switching circuit 112. The switching circuit 112 is controlled by a controller 116 to provide an output to a load. In addition, a transducer, such as Rsens, is used to transduce an electrical characteristic of the circuit or load 138 to a signal. A sensor gathers the signal associated with the transducer for further processing. A switching circuit 120 is shown in Figure 1 to electrically couple/decouple the sensor to and from the switching circuit 112.

A more detailed look at the circuit in Figure 1 shows an AC power source 130 coupled to an AC to DC converter 134, such as a full bridge rectifier having a ripple smoothing filter. The AC/DC converter outputs a DC waveform to an input 104 of a switching circuit 112. It should be understood that for purposes of this invention the meaning of a DC waveform is not intended to be limited to a strictly constant voltage; rather, waveforms having a ripple, such as those produced by conventional AC/DC converters would be included in the definition as well.

The DC signal in Figure 1 is shown electrically coupled to an input 104 of the switching circuit 112. The switching circuit 112 is preferably a full bridge inverter switching circuit commonly referred to as an H-bridge. As shown in Figure 1, this switching circuit is comprised of four switches that are controlled by control signals from a controller. Preferably, the controller is microcontroller 116. This microcontroller is preferably programmed with a pulse width modulation (PWM) program that provides control signals for the four switches. By using power transistors for the four switches, the switches can be placed in conducting or non-conducting states by these control signals from the microcontroller outputs.

A variety of pulse width modulation schemes are currently in use. These schemes are also used to supply power to a variety of different loads. Examples of such schemes are disclosed in: "Power Electronics" by Mohan, Undeland, and Robbins, Second Edition, John Wiley and Sons, Inc., 1995, which is hereby incorporated by reference for all that it discloses and for all purposes; "A Centroid-Based PWM Switching Technique for Full-Bridge Inverter Applications" by Ali Yazdian-Varjani et al., in IEEE Transactions on Power Electronics, Vol. 13 No. 1, January 1998, which is hereby incorporated by reference for all that it discloses and for all purposes; and "Electrical Machines, Drives, and Power Systems, Fourth Edition," by Theodore Wildi, Prentice Hall, 2000, which is hereby incorporated by reference for all that it discloses and for all purposes. Also, U.S. patent applications 60/126,771 filed March 29, 1999 and 60/164,326 filed November 7, 1999 are hereby incorporated by reference in their entirety for all that they disclose and for all purposes.

Two pulse width modulation schemes are illustrated in Figure 5 and Figure 6. Figure 5 shows a bipolar pulse width modulation voltage waveform which transitions between -Vdc and +Vdc. Figure 6 shows a unipolar pulse width modulation waveform. The unipolar PWM voltage signal oscillates between the ground reference voltage and +Vdc or between the ground reference voltage and –Vdc. The pulse width signals can be manipulated so as to have an effective voltage signal, e.g., a sine wave, a sawtooth wave, etc. In the case of induction motors, PWM output signals are used to approximate a sine wave. Thus, a PWM scheme can be used to manipulate the frequency and magnitude of the equivalent sine wave by varying the pulse widths and pulse spacings of the pulse width modulation output signal used to power a motor.

Regardless of the particular scheme used to control the switches in the switching circuit 112, transients sometimes will be generated when these switches, for example, transition from a conducting state to a non-conducting state, as such transitions are associated with a transition in the pulse width modulated output signal. Transients are especially a problem in the generation of a bipolar pulse width modulation signal, because each output voltage transition in the bipolar scheme involves a zero crossing by the voltage signal and a consequent current spike associated with the zero crossing for inductive loads. In addition, known conditions associated with a specific load also can result in the predictable occurrence of electrical transients.

It is important that the sensing equipment used to monitor the circuit not be significantly affected by these transients. At the same time, however, it is important to

sense for as long as possible so as to gain the most benefit from the sensing. As an example, the current in a motor load during operation is often monitored so as to prevent overload currents and/or measure the speed of the motor. By continuously monitoring the current of the motor, an overload condition can be detected at the earliest possible point in time. In addition, feedback can be provided to adjust a PWM output signal, for example, so as to adjust the speed of the motor. Similarly, the PWM signal can be shut off if a motor overload current is detected. The monitoring is therefore most useful when the electrical characteristic can be monitored for the most time possible.

Conventional systems have opted for one of two solutions for avoiding transients. In one method, a filter has been employed to reduce the effect of transients on the sensor. However, the traditional analog or digital low pass filters require a long time constant to offer the level of attenuation that is required for transients. This long time constant precludes a response time of less than 10 microseconds which is necessary to avoid damage to the switching transistors.

Another conventional attempt at satisfying this problem has been to sample the electrical characteristic at one point in time each PWM cycle, for example, using a sample and hold technique. This leaves a substantial portion of the cycle available for unmonitored problems to occur. For example, it leaves enough time for a motor overcurrent condition to arise and cause damage to the motor.

In Figure 1, the switching circuit 120 provides a solution to this problem. Figure 1 shows a sense resistor "Rsens" through which the current flowing through the motor can be derived. A microcontroller 116 receives an input signal of the voltage across the known resistor value Rsens. Therefore, it can determine the load current. This is merely one scheme for sensing an electrical condition. Other transducers could be used to provide an input signal to the processor and to represent other electrical characteristics, as would be understood by those of ordinary skill in the art. The microcontroller processes the received voltage signal; for example it can utilize the voltage as a data value in a speed control program. Also, it can act as a continuous comparator to process the sensed signal. In this way feedback could be provided for control of the output signal. Furthermore, the value can be utilized to detect an overload condition. While this configuration would be sufficient for normal operating conditions, a transient could cause the sensor to erroneously respond to the transient signal.

Thus, switching circuit 120 provides two switches electrically coupled in series between the sensor and the inverter switching circuit 112. When the switches are

in a conducting state, the sensor is electrically coupled to the inverter. When at least one of the switches is in a non-conducting state, the sensor is electrically decoupled from the inverter. Preferably the switches S5 and S6 are transistors that are controlled by signals from the microcontroller 116. Thus, when a transition of a switch in the inverter switching circuit 112 is about to be signalled by the microcontroller, the microcontroller can open either switch S5 to avoid the harmful effects of any subsequent transient. During such time, the microcontroller can disregard the input signal received by the sensor. Then, after an appropriate time, switch S5 can again be signalled to go back to a conducting state and the sensor can resume sensing. At the next transient or transition of the PWM signal, for example, switch S6 can be signalled to enter a non-conducting state and the sensing operation can be discontinued until the harmful transient effect diminishes. In this way, the effect of a harmful transient is avoided, while the sensor is allowed to continuously operate for a substantial portion of each PWM half cycle. Two switches are provided in switching circuit 120 to correspond to the two voltage transitions that occur in a pulse width modulation cycle. Thus, each switch can be controlled by a separate control signal.

Figure 2 shows an alternative switching circuit 220 that could be used in place of switching circuit 120 in Figure 1. Switching circuit 220 uses two switches electrically coupled in parallel between the sensor 216 and the inverter switching circuit. The microcontroller sends control signals to switches S7 and S8 so that at least one of the switches, preferably transistors, is conducting during normal operation. Immediately prior to an expected transient condition or output transition, the microcontroller can switch the conducting switch to a non-conducting state with a first control signal. Then, the other switch could be closed with a different control signal for the remaining normal operation of the cycle. Then, the second switch could be opened immediately prior to a transition of the PWM cycle.

Figure 3 shows yet another embodiment of a switching circuit. Switching circuit 320 can be pulsed by a single control signal twice during each PWM cycle to open the switch and disconnect the sensor from the inverter circuit. The gate of an NMOS transitor can simply be pulsed low by the microcontroller when a transition is about to occur.

While the sensor could be removed for the entire time period that a transient exists, one might choose to couple the sensor to the switching circuit, e.g., the inverter switching circuit, when the transient condition does not present a problem to the

sensor. Thus, it should be understood that the sensor does not have to be decoupled from the inverter for the entire occurrence of the transient. Rather, the sensor could be coupled to the switching circuit at either or both the beginning and end of a transient and decoupled during the harmful portion of the transient. In this way, the sensor would effectively be decoupled during the transient. Similarly, it would effectively avoid the transient, because the harmful effects of the transient will have been avoided. Similarly, the various switching circuits could be employed to electrically decouple the sensor, immediately prior to until immediately after a known transient occurrence or switch transition occurrence, so as to avoid the inherent problems with conventional sample and hold techniques.

The method for implementing the switch control system can be seen by reference to flowchart 400 of Figure 4. Figure 4 shows that an input voltage signal is received 404. The inverter switching circuit is utilized to produce an output signal 408. The output signal is output to the load to power the load 412. A sensor is electrically coupled to the inverter switching circuit 416. And, the sensor is decoupled from the inverter switching circuit to avoid transients 420, as explained above.

In addition to embodiments where the invention is accomplished by hardware, it is also noted that these embodiments can be accomplished through the use of an article of manufacture comprised of a computer usable medium having a computer readable program code embodied therein, which causes the enablement of the functions disclosed in this description. For example, this might be accomplished through the use of hardware description language (HDL), register transfer language (RTL), VERILOG, VHDL or similar programming tools, as one of ordinary skill in the art would understand. It is therefore envisioned that the functions accomplished by the present invention as described above could be represented in a core which could be utilized in programming code and transformed to hardware as part of the production of integrated circuits. Therefore, it is desired that the embodiments expressed above also be considered protected by this patent in their program code means as well.

It is also noted that many of the structures and acts recited herein can be recited as means for performing a function or steps for performing a function, respectively. Therefore, it should be understood that such language is entitled to cover all such structures or acts disclosed within this specification and their equivalents, including the matter incorporated by reference.

It is thought that the apparatuses and methods of the embodiments of the present invention and many of its attendant advantages will be understood from the foregoing description. It will be apparent that various changes may be made in the form, construction and arrangement of the parts thereof without departing from the spirit and scope of the invention or sacrificing all of its material advantages, the form hereinbefore described being merely a preferred or exemplary embodiment thereof.

WHAT IS CLAIMED IS:

1. An apparatus comprising:

an input (104) to receive a DC voltage signal;

an output (108) to provide during operation an output signal to a load;

an inverter switching circuit (112) electrically coupled with said input and with said output, said inverter switching circuit comprising a plurality of switches and configured to produce said output signal;

a sensor (116) electrically coupled with said inverter switching circuit so as to sense during operation a signal corresponding to an electrical characteristic of said load during operation;

a switching circuit (120) electrically coupled with said sensor operable to disconnect said sensor from said inverter switching circuit so as to avoid a transient from a switching transition of at least one of said plurality of switches.

2. The apparatus as described in claim 1 wherein said switching circuit disconnects said sensor from said inverter switching circuit immediately prior to until immediately after said switching transition of said at least one plurality of switches.

3. The apparatus as described in claim 1 wherein said switching circuit at least two switches (S5, S6) electrically coupled in series, said at least two switches electrically coupled with said inverter switching circuit and said sensor.

4. The apparatus as described in claim 1 wherein said switching circuit comprises at least two switches (S7, S8) electrically coupled in parallel, said at least two switches electrically coupled with said inverter switching circuit and said sensor.

5. The apparatus as described in claim 1 wherein said switching circuit comprises at least one switch (S9) electrically coupled with said inverter switching circuit and said sensor, said at least one switch operable during use so as to be opened during a first transition of a pulse width modulated output signal and operable so as to be opened during a second transition of said pulse width modulated output signal.

6. The apparatus as described in claim 1 wherein said sensor comprises a processor (116) and wherein said processor is configured to operate as a continuous comparator.

7. The apparatus as described in claim 1 wherein said inverter switching circuit is configured to generate a pulse width modulated output signal.

8. The apparatus as described in claim 1 wherein said inverter switching circuit comprises a plurality of power transistors to produce said output signal.

9. The apparatus as described in claim 1 and further comprising a motor (138) comprising a load current during operation of said motor.

10. The apparatus as described in claim 1 wherein said sensor comprises a comparator so as to provide a feedback signal for control of said output signal.

11. The apparatus as described in claim 1 wherein said sensor comprises a processor operable to receive said signal corresponding to said electrical characteristic of said load.

12. The apparatus as described in claim 1 and further comprising means for avoiding transients.

13. A method comprising:

providing a DC voltage signal;

utilizing an inverter switching circuit (112) and said DC voltage signal to produce an output signal;

outputting said output signal to a load (138);

providing a sensor (116) electrically coupled with said inverter switching circuit;

decoupling said sensor from said inverter so as to avoid transients produced by a switching transition of said inverter switching circuit.

14. The method as described in claim 13 wherein said decoupling said sensor from said inverter comprises decoupling said sensor immediately prior to until immediately after said switching transition of said inverter switching circuit.

15. The method as described in claim 13 and further comprising utilizing at least two switches (S5, S6) electrically coupled in series with said sensor and said inverter to decouple said sensor from said inverter.

16. The method as described in claim 13 and further comprising utilizing at least two switches (S7, S8) electrically coupled in parallel, said at least two switches electrically coupled with said sensor and said inverter switching circuit.

17. The method as described in claim 13 and further comprising:

utilizing at least one switch (S9) electrically coupled with said sensor and said inverter switching circuit;

utilizing a first control signal to open said switch during a first switching transition of said inverter switching circuit; and

utilizing a second control signal to open said switch during a second switching transition of said inverter switching circuit.

18. The method as described in claim 13 wherein said outputting said output signal to a load comprises providing a pulse width modulated output signal to said load; and further comprising providing a processor to process a signal received from said sensor.

19. The method as described in claim 13 and further comprising a step for avoiding transients.

20. A method comprising:

providing a DC voltage signal;

utilizing an inverter switching circuit and said DC voltage signal to produce a pulse width modulated output signal;

outputting said pulse width modulated output signal to power a load;

continuously monitoring an electrical characteristic of said load while said load is powered by said pulse width modulated output signal;

discontinuing said monitoring of said electrical characteristic of said load so as to avoid an electrical transient associated with a transition of said pulse width modulated output signal.

21. The method as described in claim 20 wherein said continuously monitoring an electrical characteristic of said load comprises monitoring for a substantial portion of a half cycle of said pulse width modulated output signal.

22. The method as described in claim 21 and further comprising:

resuming monitoring of said electrical characteristic after said transition of said pulse width modulated output signal is complete.

23. The method as described in claim 22 and further comprising:

discontinuing said monitoring of said electrical characteristics of said load so as to avoid a second transition of said pulse width modulated output signal.

24. The method as described in claim 20 wherein said discontinuing said monitoring of said electrical characteristic of said load comprises discontinuing said monitoring immediately prior to a transition of a switch of said inverter switching circuit.

25. A pulse width modulated power supply, comprising:

an input (104) to receive a DC voltage signal during operation;

a pulse width modulation control circuit (116) to generate control signals during operation;

an inverter bridge circuit (112) electrically coupled with said input so as to receive said DC voltage signal during operation and controlled by said pulse width modulation control circuit so as to generate a pulse width modulated voltage signal;

an output (108) to output said pulse width modulated voltage signal to a load during operation;

a current sense resistor electrically coupled with said inverter bridge circuit;

a processor (116) electrically coupled with said current sense resistor by a switching circuit so as to monitor a potential difference across said current sense resistor;

a control circuit (116) to control said switching circuit so as to decouple said processor from said current sense resistor during an electrical transient produced by said inverter bridge circuit.

26. A method of providing a pulse width modulated power supply, said method comprising:

providing an input to receive a DC voltage signal during operation;

utilizing a pulse width modulated control circuit to generate control signals during operation;

coupling an inverter bridge circuit to said input so as to receive said DC voltage signal during operation;

controlling said inverter bridge circuit with said control signals generated by said pulse width modulated control circuit;

producing a pulse width modulated voltage signal with said inverter bridge circuit;

outputting said pulse width modulated voltage signal to a load during operation;

electrically coupling a current sense resistor with said inverter bridge circuit;

electrically coupling a processor with said current sense resistor so as to allow said processor to monitor a voltage across said current sense resistor during operation;

controlling said switching circuit with a control signal so as to decouple said current sense resistor from said processor during a transient produced by said inverter bridge circuit.

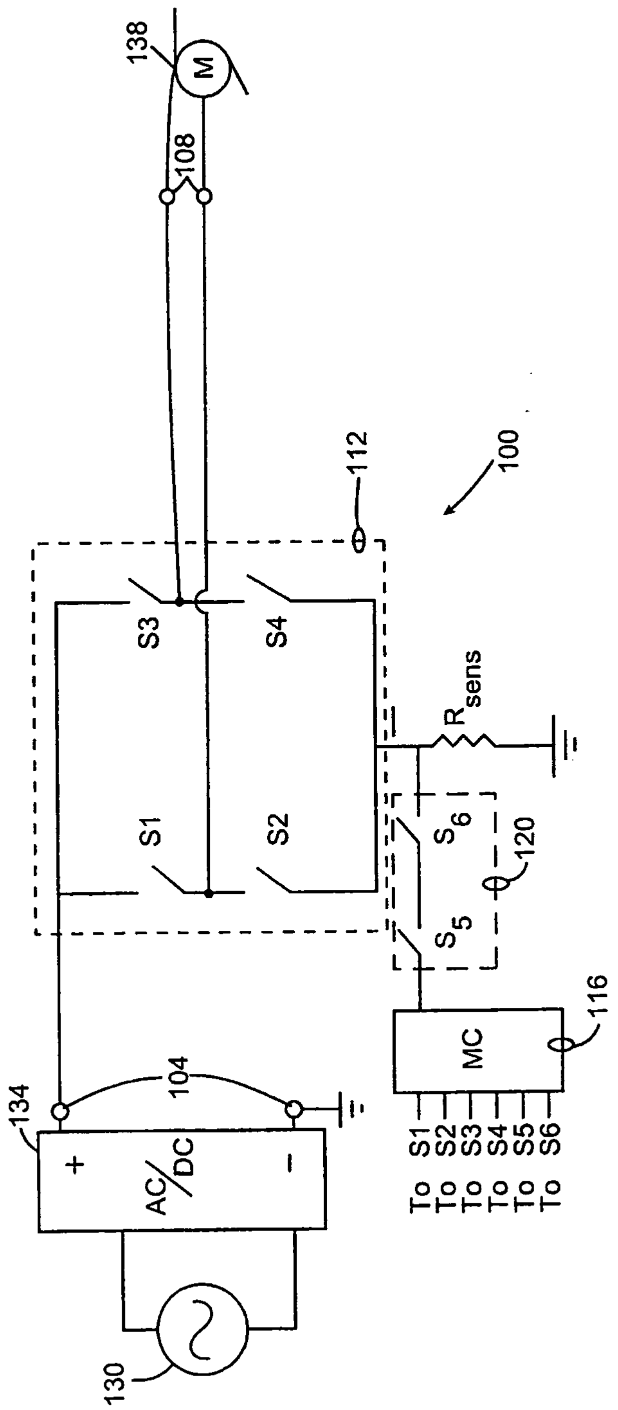
138
M
108
112
100
S3
S4
S1
S2
R_{sens}
S_6
S_5
120
MC
116
134
104
+
AC/DC
–
130
To S1
To S2
To S3
To S4
To S5
To S6

FIG. 1

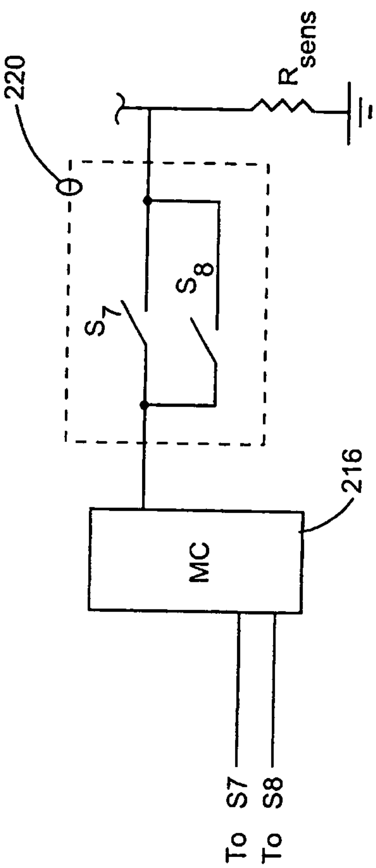

FIG. 2

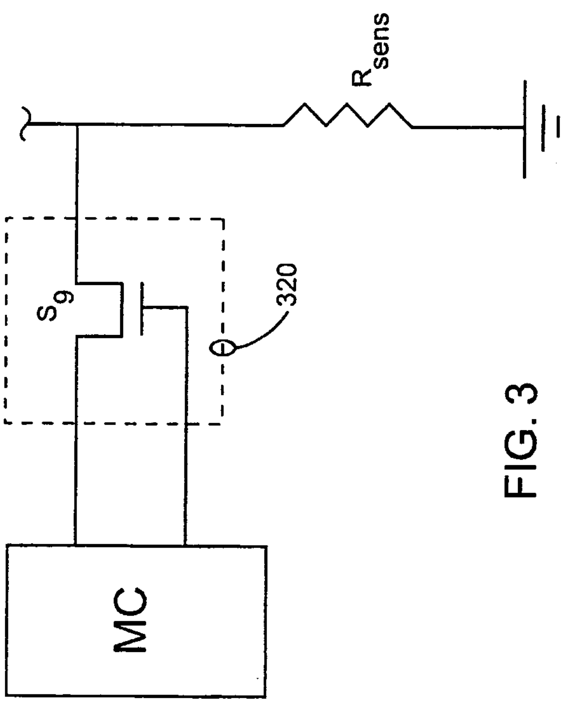

FIG. 3

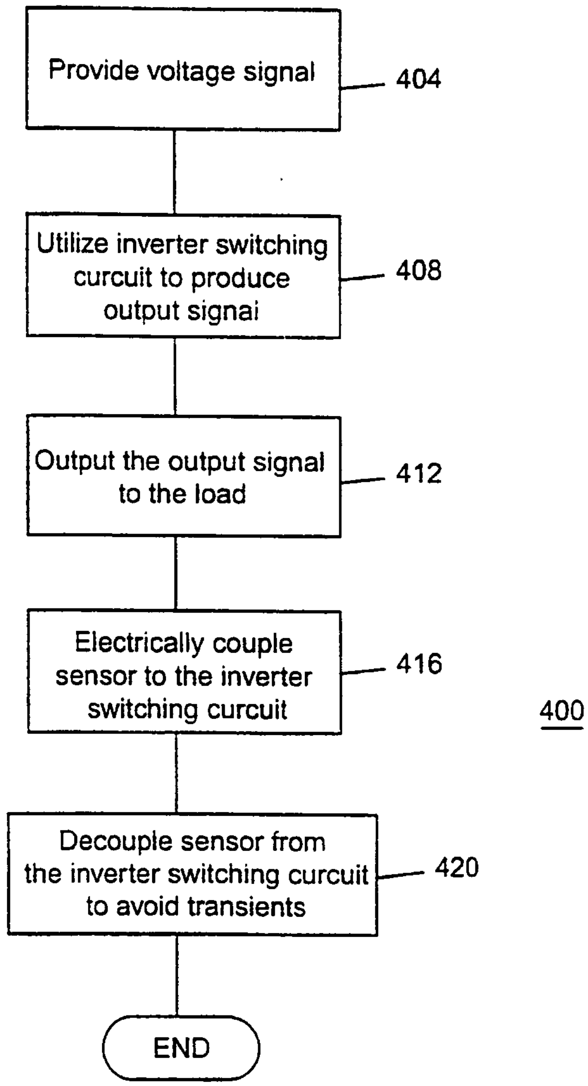
Provide voltage signal
404
Utilize inverter switching curcuit to produce output signai
408
Output the output signal to the load
412
Electrically couple sensor to the inverter switching curcuit
416
400
Decouple sensor from the inverter switching curcuit to avoid transients
420
END

FIG. 4

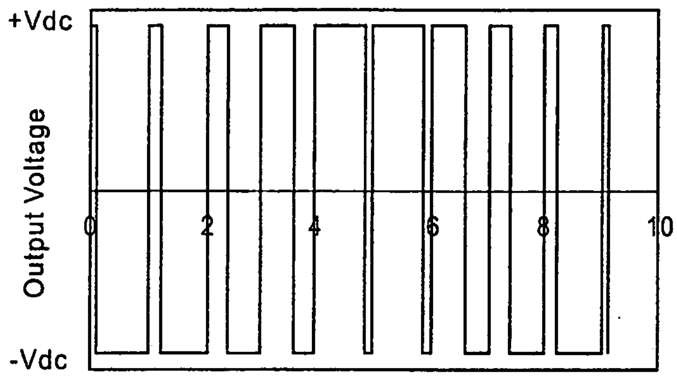
+Vdc
Output Voltage
-Vdc
0
2
4
6
8
10

FIG. 5

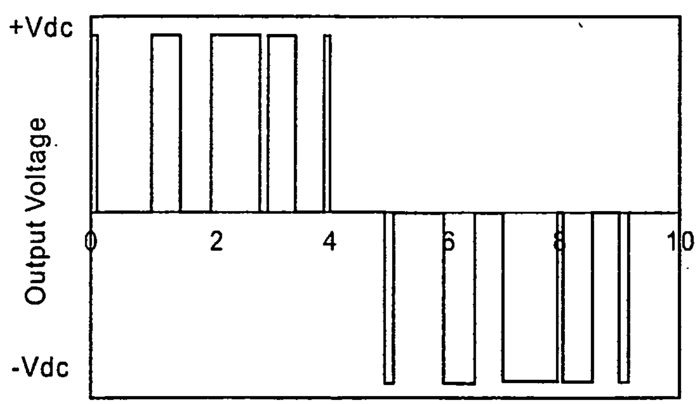
+Vdc
Output Voltage
-Vdc
0
2
4
6
8
10

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/08251

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :HO2M 1/12, 1/14
US CL : 363/39, 40, 41
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 363/39, 40, 41

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,710,699 A [King et al.] 20 January1998 (20.01.98), col. 3, line 54 to col. 6, line 26.	1-26
X	US 5,373,195 A [De Doncker et al.] 13 December 1994 (13.12.94), col. 3, line 23 to col. 5, line 13.	1-26
A	US 6,031,738 A [Lipo et al.] 20 February 2000 (20.02.00)	1, 13 & 20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search
04 MAY 2000

Date of mailing of the international search report
30 MAY 2000

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